

AMENDMENTS TO CLAIMS

1. (Currently Amended) A method for simulating thermal flows for casting/molding processes, comprising:

(a) selecting simulation modules for incorporation in an overall simulation sequence for execution by a computer, said modules including a Flow in Shot Sleeve Module, a Shrinkage Porosity Prediction Module, a Heat Transfer Fluid Line Module, and a Die Lubricant Cooling Module;

inputting initial parameter value and process conditions for the simulation sequence;
performing the simulation sequence with the computer in accordance with the parameter value and process conditions to simulate thermal flow for a casting or molding process, including:

(a) discretizing flow domain into elements having nodes and fluxing surfaces;
~~inputting initial parameter value and process conditions;~~

(b) incrementing the time by an incrementing time step;

(c) updating material balance;

(d) forming and solving momentum equations, and updating velocity and pressure fields;

(e) forming and solving energy equations, and updating temperature field;

(f) checking if parameters have converged, returning to step (d) if they have

not;

(g) determining whether an end-simulation event has occurred, returning to step (c) if it has not; and

(h) deciding whether to execute post-processor simulation modules with the computer, said post-processor simulation modules including a Mend Line Prediction Module.

2. (Currently Amended) A method, comprising:

performing a simulation of a thermal fluid flow in a die for a casting or molding process with a computer, the simulation including a model of at least one of: a shot sleeve and ram for the die as a function of ram position, shrinkage of a casting as a function of porosity, a heat transfer line embedded in the die, die lubricant cooling, and mend line formation; which includes:

establishing a finite element mesh for a domain of the thermal fluid flow;

determining mass flux relative to the finite element mesh;

updating a velocity field, a pressure field, and a temperature field relative to the finite element mesh, said updating including calculating the velocity field as a function of the pressure field; and

repeating said updating until a convergence test is satisfied.

3. (Original) The method of claim 2, which includes incrementing a simulation time interval and repeating said determination until a stop simulation criterion is met.

4. (Original) The method of claim 2, wherein said updating the pressure field and velocity field is based on conserving momentum and mass according to a control-volume based finite element formulation.

5. (Original) The method of claim 2, wherein the simulation includes the model of the shot sleeve and ram for the die, and the model is further provided as a function of one or more dwell parameters.

6. (Original) The method of claim 5, wherein said updating includes determining the temperature field according to non-coincident heat transfer between the shot sleeve, the ram, and the thermal fluid flow.

7. (Original) The method of claim 2, wherein the simulation includes the model of the shrinking of the casting as a function of porosity and further comprising:

defining an expression for the porosity as a function of density;

identifying nodes with negative pressure;

creating a reduced pressure gradient field; and

determining incremental porosity from the reduced pressure gradient field.

8. (Original) The method claim 2, wherein the simulation includes the model of the heat transfer line embedded in the die, and further comprising:

representing the heat transfer line with a number of segments each bounded by a corresponding pair of a number of nodes;
determining temperature at each of the nodes;
determining heat transfer between the die and a fluid in the heat transfer line based on the temperature of each of the nodes; and
determining the temperature field as a function of the heat transfer.

9. (Original) The method of claim 2, wherein the simulation includes the model of the die lubricant cooling, and further comprising:

providing one or more thermal properties of a spray lubricant applied to the die with a nozzle;
determining a cooling coefficient for the spray lubricant; and
computing heat loss from one or more elements of the die by application of the lubricant.

10. (Currently Amended) A method, comprising:

providing a model of a heat transfer line in a die for casting or molding, the model including a number of segments each associated with one or more element surfaces of the die and a corresponding number of nodes, the model being provided in a one-dimensional form;
determining heat transfer between the die and fluid in the heat transfer line with the model as a function of temperature at each of the nodes and Reynolds, Prandtl, and Nusselt numbers; and

with a computer, performing a simulation of ~~simulating~~ a thermal fluid flow in the die based on the heat transfer.

11. (Original) The method of claim 10, which includes linearly interpolating temperature between pairs of the nodes.

12. (Currently Amended) The method of claim 10, wherein the model is defined with ~~corresponds to the~~ a one-dimensional energy equation.

13. (Original) The method of claim 12, wherein a heat transfer coefficient is determined as a function of the Nusselt, Pandtl and Reynolds numbers.

14. (Currently Amended) The method of claim 10, wherein said performing ~~simulating~~ includes updating a temperature field of a finite element mesh representative of a flow domain for the fluid flow.

Claims 15-18. (Canceled).

19. (Currently Amended) A method, comprising:

performing a simulation of a thermal fluid flow for a casting or molding process with a computer, the process including application of a lubricant spray to a die with a nozzle;

modeling the application of the lubricant spray in the simulation as a function of a number of spray parameters, a motion profile of the nozzle, and a cooling coefficient; and determining heat loss from the die in response to the application of the lubricant spray with the simulation based on said modeling.

20. (Original) The method of claim 19, wherein the simulation includes a model of at least one of: a shot sleeve and ram for the die as a function of ram position, shrinkage of a casting as a function of porosity, a heat transfer line embedded in the die, and mend line formation.

21. (Original) The method of claim 19, wherein the cooling coefficient is determined from a look-up table.